# Psuedomonas aeruginosa (pneumonia)

Case

1. An 18-year-old woman presented with a worsening of her chronic cough for the past week. She had had a low-grade fever, as well as fatigue and shortness of breath. The cough was productive of greenish sputum that was thick and tenacious. She was diagnosed with cystic fibrosis (CF) at age 4 and had had multiple hospital admissions for respiratory infections.

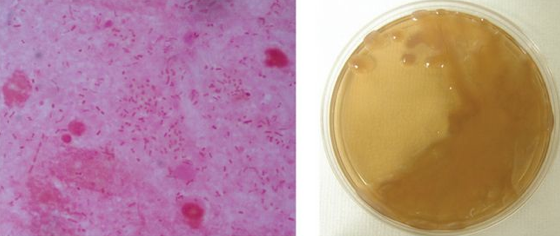
Physical Exam and CXR

1. patient was a pale, chronically ill-appearing young woman with increased respiratory effort and rapid breathing. Lung examination revealed bilateral rales and wheezing; heart exam demonstrated distant heart sounds.
2. CXR: small heart, hyperinflated lung fields, and patchy bilateral infiltrates.

DDX

1. Aspergillus fumigatus
2. Atypical mycobacteria
3. Burkholderia cepacia
4. Haemophilus influenzae
5. Pseudomonas aeruginosa
6. Staphylococcus aureus
7. Rationale: The patient has chronic pneumonia. Whereas CF patients can get common respiratory pathogens, the organisms listed above are most commonly associated with chronic infection, due to their ability to persist in respiratory secretions and in the abnormal lung environment. In particular, colonization and infection with P. aeruginosa and B. cepacia are very common. S. aureus and H. influenzae are also important pathogens. Unusual organisms such as Aspergillus and mycobacteria are less common and are often difficult to treat.

Micro Properties

1. P. aeruginosa is a Gram-negative rod in the family Pseudomonadaceae, which also includes Burkholderia and Stenotrophomonas.
2. Pseudomonads are nonspore forming and actively motile by means of their single polar flagellum.
3. These strictly aerobic bacteria are also nonfermentative and oxidase positive.
4. The typical Pseudomonas bacteria in nature might be found in a biofilm, attached to some surface. The vast majority of strains are pigmented due to a water-soluble pigment, pyocyanin (“blue pus”).
5. Colonies on routine blood agar plates have a characteristic fruity odor.
6. P. aeruginosa isolates obtained from respiratory secretions of CF patients have a mucoid appearance, which is attributed to its production of alginate capsule.
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      1. Gram stain of Pseudomonas aeruginosa from sputum of a CF patient. B, Culture of Pseudomonas aeruginosa on MacConkey agar from sputum of a CF patient. Note the mucoid (nonlactose-fermenting) colonies.

Epidemiology

1. Pseudomonads are ubiquitous pathogens, and they are flexible in their nutritional requirements.
2. These hardy organisms are capable of growing in diverse environments and are common inhabitants of soil and water (tap water and ice).
3. P. aeruginosa is one of the most important nosocomial (hospital-acquired) bacterial pathogens of humans.
4. The bacteria are borne on the unwashed hands of hospital personnel; in the hospital setting, these ubiquitous organisms are commonly found in aqueous solutions, disinfectants, ointments, soaps, eye drops, dialysis fluids, and dialysis equipment.
5. Equipment that requires a wet, body temperature environment, such as dialysis tubing and respiratory therapy equipment, is particularly susceptible to contamination.
6. Transmission occurs by ingestion of, or contact with, contaminated water or ice; aerosolization of contaminated liquids; penetration by contaminated objects; and ingestion of Pseudomonas-laden foods (e.g., tomatoes).

Pathogenesis

1. CF patients, with a defective CFTR gene on chromosome 7, have an abnormal chloride channel with resultant secretion of abnormally thick mucus in the large airways.
2. Early in life, the trachea becomes colonized with P. aeruginosa, mediated by flagella and pili. The receptor on tracheal epithelial cells for Pseudomonas pili is sialic acid (N-acetylneuraminic acid).
3. Bacterial surface-bound exoenzyme S also serves as an adhesin for glycolipids on respiratory epithelial cells. At some time after colonization, bacteria move down to the bronchi and undergo a phenotypic shift, becoming mucoid owing to de novo alginate capsule. They lose their ability to move by shutting down the production of the polar flagellum, establishing a permanent and localized chronic infection.
4. The alginate capsule, a repeating polymer of mannuronic and glucuronic acid, develops into a matrix of the Pseudomonas biofilm, which protects the colonizing bacteria from phagocytosis and other host defenses such as the ciliary action of the respiratory tract, antibodies, and complement.
5. Host factors favoring persistence of P. aeruginosa in the lung are (1) the impaired ability of bronchial epithelial cells to clear P. aeruginosa and (2) increased mucin production by bronchial epithelial cells, stimulated by P. aeruginosa LPS.
6. A vigorous and chronic neutrophilic inflammatory response is mounted in the infected large airways by the bacterial cell-wall LPS. This neutrophilic inflammatory response interferes with pulmonary function and is, in fact, a major cause of morbidity in CF.
7. Despite the intense inflammation within the tracheobronchial tree, bacteremia in these patients is very rare because of a high level of antibodies to various excretory antigens of P. aeruginosa.
8. The three secreted products, elastase, exotoxin A, and phospholipases, also contribute to lung tissue damage.
   1. Elastase hydrolyzes elastin and collagen.
   2. Exotoxin A causes ADP-ribosylation of EF-2, resulting in inhibition of protein synthesis and ultimate cell death.
   3. Phospholipases hydrolyze phospholipids of eukaryotic membranes, resulting in host cell death.

Treatment

1. Empirical therapy usually includes an extended- spectrum penicillin (e.g., piperacillin), cephalosporin (e.g., ceftazidime), or a carbapenem (e.g., imipenem) and an antipseudomonal aminoglycoside (e.g., tobramycin).
2. The proper empirical choice of antibiotics should be based on continuous surveillance of drug sensitivity. The resistance pattern among Pseudomonas strains varies from hospital to hospital and changes with time. Directed therapy of chronic pneumonia due to mucoid strains of P. aeruginosa or Burkholderia cepacia should be based on the susceptibility profile of the clinical isolates.
3. NOTE P. aeruginosa bacteria are resistant to many commonly used antibiotics, including first- and second-generation penicillins and cephalosporins, tetracyclines, chloramphenicol, and macrolides. However, newer quinolones with antipseudomonas activity have been useful in the management of some of the clinically diverse infections (Table 23-2) due to this opportunistic pathogen.

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| Syndromes | Clinical Features |
| Normal hosts | Otitis externa (swimmer’s ear)Folliculitis (hot tubs, swimming pools)Puncture-wound osteomyelitis (e.g., a nail puncture through a tennis shoe) |
| Abnormal hosts Local invasion | Invasive otitis externa (a slowly progressive, life-threatening infection if untreated). In patients with diabetes mellitus, P. aeruginosa colonizing the external auditory canal may invade along the cartilage-bony interface (theducts of Santorini) and infect the soft tissues below the temporal bone.Urinary tract infections (complicated). Whereas P. aeruginosa rarely causes UTIs in normal hosts, it is one of the more frequent etiologies of UTI in immunocompromised or hospitalized patients, often in association with the use of an indwelling bladder catheter (Foley catheter). |
| Invasion with systemic spread | Bacteremia (sepsis). Predisposing conditions include hematologic malignancies, immunodeficiency relating to AIDS, neutropenia, diabetes mellitus, severe burns, and wound infections. Most cases of Pseudomonas bacteremia (20% of nosocomial blood stream infections) are acquired in hospitals and nursing homes. LPS-associated endotoxin causes a systemic inflammatory respiratory syndrome (multiple-organ dysfunction), thrombocytopenia (ecthyma gangrenosum), shock, and death.Pneumonia. Respiratory infections caused by P. aeruginosa occur almost exclusively in individuals with a compromised lower respiratory tract or a compromised systemic defense mechanism, or in ICU patients supported by respiratory therapy equipment (ventilator-associated pneumonia). |

Prevention

1. There is no vaccine to prevent infection.
2. CF patients have a high likelihood of developing colonization; they should be educated about the transmission of organisms from others.
3. Proper maintenance of water reservoirs is important in reducing the likelihood of spread from environmental sources.
4. In the hospital, contact and droplet precautions, with regular hand washing after patient contact, are important in preventing nosocomial infections.
5. Careful attention to aseptic technique during procedures, and cleaning and disinfecting respiratory therapy equipment used in health care settings—as well as in the home—also help reduce risks.